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ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY, IN AWARDING THE BRUCE MEDAL TO GEH. RATH DR. ARTHUR AUWERS.

BY R. G. AITKEN.

In conformity with the statutes for the bestowal of the BRUCE Gold Medal of the Astronomical Society of the Pacific, the Board of Directors of the Society held a special meeting on the last Saturday of November, 1898, to consider the nominations for the award of the medal for the present year which were made by the Directors of the Berlin, Greenwich, Paris, Harvard, Yerkes, and Lick Observatories.

It becomes my pleasant duty this evening to announce to the Society that by the unanimous vote of the Board of Directors the award was made to Geheimer Rath Dr. ARTHUR AUWERS, of Berlin.

Dr. AUWERS'S title to this mark of our consideration and respect may perhaps be most briefly stated in the words of our distinguished medalist of 1898. In his "Reminiscences of an Astronomer," in the *Atlantic Monthly*, Professor SIMON NEWCOMB says:—

> "To-day, AUWERS stands at the head of German astronomy. In him is seen the highest type of the scientific investigator of our time, one perhaps better developed in Germany than in any other country. The work of men of this type is marked by minute and careful research, untiring industry in the accumulation of facts, caution in propounding new theories or explanations, and, above all, the absence of effort to gain recognition by being the first to make a discovery. When men are ambitious to figure as NEWTONS of some great principle, there is a constant temptation to publish unverified speculations which are likely rather

to impede than to promote the advance of knowledge. The result of AUWERS's conscientiousness is that, notwithstanding his eminence in his science, there are few astronomers of note whose works are less fitted for popular exposition than his. His specialty has been the treatment of all questions concerning the positions and motions of the stars. This work has required accurate observations of position, with elaborate and careful investigations of a kind that offer no feature to attract public attention, and only in exceptional cases lead to conclusions that would interest the general reader. He considers no work as ready for publication until it is completed in every detail, showing in this a conscientiousness which his fellow-astronomers may sometimes have reason to regret, owing to the length of time they have to wait for his conclusions."

These words from one who is himself in the front rank of the scientific investigators of our time offer reason enough for our award. At the same time, the strictly technical and theoretical character of Dr. AUWERS's work, to which Professor NEWCOMB calls attention, indicates the propriety of dwelling in more detail to-night upon the achievements of one who has done so much to advance and systematize our knowledge of the stars.

Born in Göttingen, on September 12, 1838, he entered the gymnasium of his native city, and was early attracted to the science of astronomy — probably through the influence of WINNECKE; for the latter, writing in 1854 of meteor observations made in July of that year by PAPE and himself, says that they were materially assisted on the first few nights by their young friend, Herr A. AUWERS (then a lad of sixteen). Later on, WINNECKE writes of a new nebula, found by Herr AUWERS in 1854.

Having decided thus early upon his life-work, we find him for the next few years continuing his university studies, and employing his leisure in observing variable stars, comets, asteroids, and nebulæ, and in computing orbits and ephemerides of comets and asteroids.

In 1859, he became assistant astronomer at Königsberg, and for three years varied his theoretical studies by observations with the heliometer made famous by the work of BESSEL. In addition to valuable series of measures of comets, asteroids, nebulæ, variable stars, and double stars, this resulted in an admirable series of observations for the parallax of certain stars, together with an exhaustive investigation of the instrument itself and a discussion of the methods of reduction of heliometer observations. It was with this instrument also, on May 21, 1860, that AUWERS, while observing variable stars, found the new star in Messier 80, the so-called *Nova Scorpii.*

In 1862, his inaugural dissertation for the degree of Doctor of Philosophy was published at Königsberg. This was the first part of his memoir on "Variable Proper Motions," and included an orbit of *Procyon* based on meridian observations. In this research he struck the key-note of his future life-work—"the treatment of all questions concerning the positions and motions of the stars."

Leaving Königsberg in the summer of 1862, Dr. AUWERS went to Gotha as assistant astronomer, and for some time continued his work at the observatory there under the guidance of P. A. HANSEN. In 1866, he was called to Berlin as the successor of ENCKE in the position of Secretary of the Royal Prussian Academy of Sciences, Section of Mathematics and Physical Sciences — a position he still holds. Since 1866, he has not, so far as I am aware, been officially connected with any observatory; but he has at times taken active part in the observing work at Berlin, at the Cape of Good Hope, and elsewhere, and has also held many positions which indicate the confidence his fellow-astronomers have in his administrative ability. Thus, he has repeatedly been President of the Astronomische Gesellschaft, was one of the first editors of the *Vierteljahrsschrift* of that Society, chairman of the commission in charge of the A. G. zone work, and chairman of the German Commission on the Transit of *Venus*.

Though a skillful and industrious observer, Dr. AUWERS is pre-eminently a theoretical astronomer, and his researches have been conducted, broadly speaking, toward the achievement of two main objects — (1) a better knowledge of the value of the solar parallax, and (2) the reduction of star-catalogues to a common fundamental system, so as to afford the means of utilizing readily all existing data in the accurate determination of the positions and motions of the fixed stars. Both investigations demand for their successful pursuit the highest order of skill, rare judgment, and a patience and an accuracy in the treatment of minute details that is given to but few minds. The comparison of star-catalogues and the formation of a fundamental system of star-places, for instance, involves careful consideration of the methods of observation and reduction used in every existing star-catalogue; of the values of the constants of precession, nutation, aberration, refraction, etc., adopted by each computer; of the nature and stability of the instruments used in the observations; of the systematic errors of observation due to the star's position and magnitude; of the personal equation of the observer; of the proper motions of the stars themselves;—in fact, of almost endless questions, hardly to be appreciated except by one engaged in similar investigations.

This problem was attacked by AUWERS, in a preliminary way, at an early age, as we know from the fact that in 1861 he published in *Astronomische Nachrichten*, at the instance of BRUHNS, FOERSTER, and others, the systematic corrections necessary to reduce a number of different catalogues to the system of the "Tabulæ Reductionum" of WOLFER'S. These corrections he had been using, he says, for some time in determining the accurate positions of the comparison-stars for his observations of comets and asteroids.

A far more important step was taken in 1865, when he published his "Tables for the Reduction of the Declinations of Various Star Catalogues to a Fundamental System," and a few months later followed this with a discussion of the "Declinations of the Fundamental Stars." In these papers all existing material of value was carefully considered and the foundation laid for a homogeneous system of Declinations.

Meanwhile some special investigations suggested by this general problem had engrossed AUWERS'S attention, as we see from the subject of his Inaugural Dissertation, viz: the variable proper motions of certain stars.

In 1844, BESSEL announced that, instead of moving at a uniform rate in a straight line, as do all other fixed stars with known proper motions, *Sirius* and *Procyon* showed evidences of variable motion — the former in Right Ascension, the latter in Declination; and in discussing the possible explanations of such motion, concluded that the only tenable hypothesis was that the bright star was the visible member of a binary system. In the case of the two stars under consideration, BESSEL did not feel that the observations then available warranted any more definite conclusion than that the motion was variable, and showed a period of about half a century.

In 1851, Dr. C. A. F. PETERS repeated the investigation of the Right Ascensions of *Sirius*, confirmed BESSEL'S conclusion of variable proper motion, and determined the orbit of the system with a revolution period of about fifty years. Ten years later, SAFFORD investigated the Declinations in a similar manner, and found the motion variable in this co-ordinate also, and showed that PETERS'S orbit, which was based on Right Ascensions only, would account for the motion in Declination with but small outstanding errors.

At this time AUWERS undertook a complete reinvestigation of this question with respect to both stars, examining with all possible care all the available observations in both Right Ascension and Declination, including in the case of *Sirius* 7,000 in Right Ascension and 4,500 in Declination. His results for *Procyon* were that the star revolved in a sensibly circular orbit in a period of about forty years. This part of the research formed, as has been said, his thesis for the Doctor's degree in 1862. His investigation of the motion of *Sirius* was published some two years later, and resulted in an orbit decidedly eccentric with a revolution period of fifty years. As is well known, this orbit for the theoretical companion was very accurately followed by the small attendant discovered by A. G. CLARK, in 1862. When the latter star was lost in the brilliant rays of its primary, in 1892, Dr. AUWERS again examined this system, taking into account the micrometer measures of the faint CLARK companion as well as the meridian observations of *Sirius* itself, and proved definitively that this companion accounted for the variable motion of the bright star first noticed by BESSEL.

In all of these investigations Dr. AUWERS had felt the need of a more accurate determination of the proper motions of stars than was possible from the catalogues then in existence. In such investigations BRADLEY'S catalogue was by far the most important. Not only were his observations, for which the epoch was about 1755, the first that were at all comparable in system and accuracy with those of modern times, but they were also far superior to those of his successors for half a century or more, to the time of BESSEL and STRUVE.

These observations were first reduced in 1819, nearly fifty years after BRADLEY'S death, by BESSEL, who indicated his estimate of their importance by the title, "Fundamenta Astronomiæ." That this reduction was made by BESSEL is sufficient guaranty of its excellence; but in the half-century following its publication the rapid progress of astronomy in every line led to a more accurate knowledge of the fundamental constants, and to more refined methods of the reduction of meridian observations. It also became evident from PETERS'S investigations in 1855 that some of BESSEL'S assumptions respecting the transit instrument used by BRADLEY were erroneous.

As all these errors would seriously affect the proper motions derived from the BRADLEY stars, a new reduction was highly desirable, and this was undertaken in 1864, by WINNECKE, at Pulkowa. Illness, however, compelled him to give up the work; and in 1866 it was taken up by Dr. AUWERS. All his previous work had been fitting him for such a task, and the result was a "masterpiece and a model." AUWERS based his work upon specially collated copies of BRADLEY'S original records, and spared no pains to insure the utmost accuracy in reduction. No detail was too minute, no computation too tedious, that might in any way improve the results.

In ten years this great task was substantially completed, and in 1877 the manuscript of the second volume, containing the individual observations in Right Ascension and Zenith Distance, was given to the printers. Four years were needed to get it through the press, and it was not distributed until 1882. A year later, on Dr. AUWERS'S return from the Transit of *Venus* Expeition to Patagonia, the third volume was sent to the printer, but it was not distributed until 1888. This volume contains an extensive introduction and the catalogue proper. BRADLEY'S star-places are given for the epoch 1755, and also for the epoch 1865. For the latter epoch a new catalogue of the same stars, based almost entirely upon Greenwich observations between 1854 and 1867, is also given by AUWERS, who determined the proper motions of the stars by comparing the two catalogues. The volume also contains all necessary data to reduce the stars to any desired epoch. The first volume will contain a number of special investigations connected with BRADLEY'S work, and also the reduction of his observations of the planets. The manuscript was sent to the printer nearly three years ago, but the volume has not yet been issued.

In many respects this has been Dr. AUWERS'S most important work, and as such it won for him the gold medal of the Royal Astronomical Society in 1888, and, in connection with his other work, the Watson gold medal of the National Academy of Sciences, of Washington, in 1891. In another sense, however, it is only another contribution towards the solution of the great problem of forming a homogeneous system of star-places, for it affords the means of a more accurate determination of the proper motions of the stars, and thus diminishes the difficulty of comparing catalogues of different epochs.

In the mean time an enterprise was inaugurated by the Astronomische Gesellschaft which promised the practical realization of a homogeneous star-catalogue, based not on existing observations, but upon a complete reobservation of the sky. At the meeting of the Gesellschaft in Leipzig, in 1865, Professor BRUHNS offered a resolution declaring that the Astronomische Gesellschaft considers it necessary that all stars to the ninth magnitude which are found in the Bonn D. M. be observed with meridian-circles, and commissions its Council to organize and superintend the execution of this work. The formulation of the preliminary plan was left to ARGELANDER, after considerable discussion. This plan, revised by a committee consisting of ARGELANDER, BRUHNS, and WINNECKE, was presented at the Bonn meeting of the Society in 1867. It limited the work to the stars lying between — 2° and + 80° Declination; provided that the observations should be differential, that every star should be observed at least twice; and suggested that the entire field be divided into zones extending over 5° or 10° in Declination. Each observatory that desired to share in the undertaking could then select the zone best suited to its location and equipment. This plan, in its essential features, was adopted, and various observatories volunteered to share in its execution. The list of fundamental stars, selected by ARGELANDER, was published the following year. These were to be accurately observed at Pulkowa.

This plan was modified in many of its details by the Council of the society, and the final form of the program to be followed was presented, for the Council, by Dr. AUWERS at the Vienna meeting, in 1869. The preparation of the fundamental catalogue of 539 stars was also left to Dr. AUWERS; so that what is now known as the A. G. system is, in one sense, AUWERS'S system, and the catalogue of the Astronomische Gesellschaft, when completed, will be the practical realization of his endeavor to form a homogeneous catalogue of stars.

As one of the secretaries of the Gesellschaft, and later as chairman of the Zone Commission, Dr. AUWERS has had an active and influential part in the supervision of this work from its beginning. Not content with this, however, he gladly accepted Professor FOERSTER'S offer to assist in observing the 10° zone set apart for the Berlin Observatory. The southern half of this zone — from + 15° to + 20° Declination — was put in his charge, and the work begun early in 1869. The necessary observations — about 25,000 in number — were nearly all made before the end of 1871; but owing to the pressure of other work, especially the new reduction of the BRADLEY stars, Professor AUWERS did not press the work of reduction for some years. When he did take up this task, he extended his investigations to such bounds that the catalogue, which was finally issued in 1896, became really a comprehensive treatise on the positions and proper motions of the stars in the zone in question; for in addition to the catalogue proper the volume includes an elaborate comparison of the observed positions with all those found in previous catalogues, and from these comparisons a careful determination of the proper motions.

A few years after the adoption of the original plan, it was decided to extend the A. G. catalogue to the southern skies (to — 23° Declination) as well, and the preparation of the necessary catalogue of southern fundamental stars was also intrusted to Dr. AUWERS.

As new material has become available through the highly accurate observations of the fundamental stars made in recent years with the best meridian-circles of our time, Dr. AUWERS has rediscussed and refined his fundamental catalogues. Still further to increase their practical convenience and usefulness as a standard of reference, he has also taken the time to construct extensive tables of systematic corrections for the reduction of nearly all existing catalogues of importance to the A. G. system.

These researches constitute Dr. AUWERS'S most important contributions to the progress of astronomy; but no inconsiderable portion of his scientific life has been devoted to the solution of the other problem I have mentioned — the more accurate determination of the value of the solar parallax.

In 1874, and again in 1882, elaborate preparations were made by astronomers to observe the transits of *Venus*, with the view of getting a better knowledge of this constant. There were many difficulties known to be inherent in this method; but astronomers at that time were not agreed upon any better one that was so independent of other constants, and it was hoped that the number of the independent observations and the variety of instruments used would give sufficient data to furnish a reliable conclusion.

Dr. AUWERS was placed in charge of one of the German expeditions in 1874 (to Luxor), and in 1882 had charge of the German expedition to Punta Arenas, Patagonia. Besides this, he was chairman of the German Transit of *Venus* Commission, and in that capacity directed the general plan of observation for all the parties sent out by the German Government, and, later, had charge of the reduction of the results. These observations and their discussion are printed in an imposing series of volumes, of which Vols. II, III, IV, V, and VI have thus far been issued.

Needless to say, the work was planned with all possible care, and the discussion carried out with the thoroughness and accuracy which characterize all of Dr. AUWERS'S work. But though the resulting value of the parallax constant is thus probably the best that can be attained by this method, — which is not likely to be tried again, — it appears from other considerations to be too large, and will be of little practical value in astronomical investigations.

Another method, first proposed by Professor GALLE, of Breslau, is free from many of the difficulties besetting the observation of the transit of *Venus*, and, as the event has shown, is the most accurate independent method yet tested. This consists in observing from different stations the displacement of the nearer asteroids among the stars at about the time of opposition. After some experiments, Dr. DAVID GILL, with the co-operation of Dr. AUWERS, and of Dr. ELKINS, of Yale, planned and executed an elaborate test of this method in 1888 and 1889 by concerted heliometer observations of the minor planets *Iris*, *Victoria*, and *Sappho*, at different observatories in the northern and southern hemispheres. Dr. AUWERS had a direct share in the observations themselves, going to the Cape of Good Hope to observe *Victoria* with Dr. GILL, in 1889.

The important work of constructing the catalogue of definitive positions of the comparison stars from the meridian observations, which had been especially instituted at a number of different observatories, was also intrusted to him. The final value of the solar parallax resulting from this investigation is undoubtedly the most accurate yet obtained, and is probably very near the truth.

This brief and imperfect account of Dr. AUWERS'S contributions to the progress of the science to which he has devoted his life is utterly inadequate in its descriptions of the researches mentioned in it; and many others — minor indeed, comparatively speaking, but yet of great interest and value to astronomers — have not even been named. In spite of its incompleteness, however, enough, I think, has been said to show that Professor NEWCOMB'S tribute, which I have quoted, is well deserved; and that the trust placed in our Society by Miss BRUCE, to award this medal "for distinguished services to astronomy," has been kept in spirit as well as in letter, by our bestowal of it upon Geheimer Rath Dr. ARTHUR AUWERS.

In his necessary absence to-night, I hand the award to you, Mr. Secretary, to transmit to Dr. AUWERS, with the assurance of our appreciation of his great achievements, and the expression of our hope that, in the investigation of the many problems still waiting to be solved, his fellow-workers may long enjoy the advantage of his co-operation and counsel.

March 25, 1899.

SOME PHOTOGRAPHS OF THE GREAT NEBULA IN *ORION* WHICH ARE DIRECTLY COMPARABLE WITH DRAWINGS.

By JAMES E. KEELER.

In an article printed several years ago in these *Publications*,[*] I considered at some length the effect of a supposed non-homogeneous structure of the nebulæ on their forms as shown respectively in drawings and in photographs. The argument was briefly this: The nebula is seen by one set of rays, and photographed by a different set, so that the two different impressions cannot be expected to agree, unless these sets of rays are emitted in the same proportions by all parts of the nebula. The same considerations apply to any landscape; and it is only because the objects in a landscape have sharply defined outlines that the differences between the photograph and the view seen by the eye do not strike us more forcibly.

I do not by any means assert that the cause here mentioned is chiefly responsible for the differences between drawings and photographs of nebulæ. These differences are no doubt mainly due to the nature of the object, and the extreme difficulty of drawing faint and diffuse forms. It is sufficiently obvious, moreover, to any one who looks over such a collection of drawings as Professor HOLDEN has brought together in his "Monograph on the Central Parts of the Nebula of *Orion*," that many of the

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[*] Vol. VII, p. 279, (1895).